REMARKS

35 U.S.C. §103(a)

Applicants assert that the invention as claimed in the currently amended independent Claim 1 is not rendered obvious by the prior art and not by Terao, Davis or Yamaoka, whether alone or in combination.

The invention as claimed in currently amended independent Claim 1 discloses a method for supporting and positioning a payload effecting simultaneous vibration isolation and large force and stroke position actuation comprising the steps of supporting the payload on a frictionless gas piston of gas bearing construction, commanding gas pressure applied to the frictionless gas piston with a pneumatic servo-valve, measuring the error in pressure resulting upon the frictionless gas piston, and applying a magnetic force in parallel to the resulting pressure in proportion to the measured pressure error.

For the particular and significant fact that the Terao device mechanically conjoins a stiff mechanical element, a ball screw, to the air piston of that device, the Terao device is not and cannot be an isolator. The Terao device cannot control the force applied to the payload so to provide vibration isolation as well as position actuation; it cannot prevent undesired dynamic forces applied at the base of the device from being transmitted to the payload end of the device.

Particularly, the Terao device does not and cannot perform the step of applying a magnetic force in parallel to the resulting pressure in proportion to the measured pressure error, as does the presently claimed invention. In the Terao device, as undesired dynamic forces are applied to its base, commensurate undesired dynamic forces are applied to its

payload end. This occurs for practically all dynamic force frequencies, from the very low to the very high, because of the great stiffness of the ball screw. The inherent compliance of the air column beneath the piston within Terao is of no consequence in terms of providing isolation because the large stiffness of the ballscrew dominates and results in an equally stiff overall device.

The Terao device does not teach or suggest the measurement of the error in pressure resulting upon the gas piston, as does the present device. Rather Terao teaches the measurement of position error, and the subsequent control of position. For this fact Terao teaches away from the method of the present invention. Terao, through its incorporation of a ball screw, applies an indeterminate mechanical force to the piston based on the desired workpiece position. The air piston of Terao initially positions and supports the static load of the table and any attached workpiece. The ballscrew then provides the final positioning of the workpiece. The Terao device, in using the ball screw to engage and provide final position of the piston and workpiece, suffers from both the inherent stiffness of, and inability to back drive the ballscrew. These attributes coupled with the low dynamic force response of the drive motors and pulleys prevent the Terao device from affording any significant vibration isolation capability.

Because of these features of the Terao device and to its significant limitation, the Terao device positions its workpiece regardless of the body accelerations that may exist on the workpiece or the dynamic displacement disturbances at the base of support for the device. Because of the stiffness of the load path through the ball screw, the Terao device transmits whatever dynamic displacement disturbances the base experiences onto the workpiece.

In contrast, the present invention provides vibration isolation at high frequency and also provides position control via force control through the error correcting application of a magnetic force in parallel to the resulting pressure of a commanded gas pressure in proportion to the measured pressure error. This has not been done before and the combination is not obvious.

Within the broad flexibility of the present invention, as claimed in currently amended independent Claim 1, a variety of support and positioning methods may be effected in conjunction with broadband vibration isolation. In a preferred embodiment the present invention effects a force generation method. The method provides a support stiffness that can be made as soft as desired simply by configuration of the magnetic force feedback step. At low frequency, the method provides a stiffness approaching zero simply by commanding a constant force equal to the external static load. The Terao device has no such capability, and it does not teach or suggest such ability alone or in combination with any other device of the prior art.

The Terao device, through use of the ballscrew accomplishes refined position control on the pneumatic cylinder, but it has very little bandwidth, i.e. it could not produce a position output that would accurately track an input signal if a command waveform called for it to move back and forth over a significant distance at a rate of more than, at most, a few cycles per second.

Applicants argue further, within the present invention as claimed in currently amended independent Claim 1, that because the method incorporates the step of supporting the payload on a frictionless gas piston of gas bearing construction, the invention allows for the instantaneous pneumatic force and its measured error to be

determined and corrected by the magnetic force application extremely accurately. This force correction is provided for through the steps of measuring the error in pressure resulting upon the frictionless gas piston and of applying a magnetic force in parallel to the resulting pressure in proportion to the measured pressure error.

The Examiner asserts that Davis and Terao combine to render the present invention obvious. Applicants assert that Davis teaches damping modulation within an isolator and that Terao teaches refined position control within an actuator with concomitant and inherent exclusion of vibration isolation, and the combination of the two do not render the present invention obvious. Applicants assert that alone or in combination, Terao and Davis do not teach or suggest a method for supporting and positioning a payload such that vibration isolation and large force and stroke position actuation is simultaneously achieved, as does the present invention.

The Davis device is an isolator, and in structure and concept only a very modest stroke actuator. Davis does not disclose a pneumatic actuator or disclose or teach an actuation method providing any significant stroke relative to the size of the device. Large displacement actuation is not available within the concept of the device since actuation is gained only through the fluid pressurization and modest fluid movement offered by the internal electromagnetic actuator. The possible motion available by this approach is further constrained by the D-shaped flexure piece which forms essential part of the damping fluid chamber. As a result, the Davis device actuation performance is substantially limited due to the opposed needs of limiting the size and stiffness of the D-shaped flexure so to provide lower frequency vibration isolation versus the need for increasing the D-shaped flexure stiffness so to provide greater load carrying capability.

The teaching effected by Davis is that an electromagnetic actuator can vary the pressure of the damping fluid used within an otherwise passive damping mechanism. Davis does not teach or suggest applying a magnetic force in parallel to the resulting pressure of a commanded gas pressure where that pressure is applied to a gas piston, and further there is no teaching or suggestion of applying a magnetic force in proportion to the measured pressure error applied to the gas piston.

Examiner states that Terao differs only in the type of magnetic actuator that is used and that it would have been obvious to use a linear motor in place of the rotational motor used to drive the ball screw.

Applicants argue that it is neither correctly, nor simply, a matter of substitution of a linear magnetic motor for a rotational one that distinguishes the present invention from Terao and Davis. The Terao device manages relative displacements, and the substitution suggested would simply result in a linear motor driven ball screw. The incorporation of a ball screw with a pneumatic actuator for obtaining refined positioning capability prevents one from achieving significant vibration isolation.

Applicants assert that it is not obvious to perceive how one modifies a Terao device, a refined position control actuator utilizing a ball screw conjoined with a pneumatic piston, with attributes of the Davis device, where a magnetic actuator modifies the fluid pressure of passive damper, to get the attributes of the present invention.

It is the application and management of applied force to a payload that makes the present method unique and non-obvious. The prior art speaks to position control within actuators, as in Terao, or damping modification within otherwise passive isolators, as in Davis. The prior art does not combine to teach or suggest a method of force control that

achieves large stroke and force position actuation with simultaneous vibration isolation, as does the present invention.

Device actuation state variable control, and particularly overall device output force control, is not provided by the Davis device. Applicants assert that Davis is completely non-instructive on how such control could be effected within the Terao device. Davis does not utilize its electromagnetic actuator for error correcting magnetic force generation. Further, the Davis device does not incorporate pneumatic actuator elements or features for providing large stroke and load carrying capability, as does the present invention.

Yamaoka teaches an actuation means, but nothing of isolation and force control. The Yamaoka device uses electromagnetics to generate the entire actuation force developed by the device and incorporates no passive means for transmitting force from one end of the device to the other. Yamaoka discloses an electromagnetic strut and does not incorporate the elements or features of a large force pneumatic actuator. There is no teaching within Yamaoka for the effecting of a magnetic force in such proportion to negate the measured error in the state variable of a pneumatic actuator.

The Applicants assert that beyond the distinctions of teaching and concepts drawn, that the presently claimed invention as claimed in independent Claim 1 is non-obvious particularly for its distinct and marked improvement in performance relative to the prior art.

The presently claimed invention provides significantly larger payload carrying capability, higher accuracy dynamic position actuation capability, as well as significant broadband vibration damping and isolation ability beyond the state of the prior art. The

presently claimed invention can support large payloads with large payload-to-base position excursions and track a force command at rates of 20-40 cycles per second. The Davis device cannot support large payloads or provide for large position excursions. The Terao device as disclosed has no vibration isolation capability, and the incorporation of isolation features from Davis could be of no effect without removal of essential elements of the Terao concept.

Applicants respectfully submit that the bandwidth of vibration isolation, the degree of lifting force available from a device, as well as attributes such as range of stroke, are not features of a device but performance characteristics to which it can be compared to devices of the prior art. Such performance attributes do not need to be claimed as features of the device to be included within the consideration of non-obviousness, and therefore vibration isolation bandwidth performance, though not claimed for not being a feature, is not moot to a determination of non-obviousness. Applicants reassert in consequence that the presently claimed invention is non-obvious for the substantial performance improvement it gains in isolation bandwidth performance combined with large force and stroke capabilities when viewed relative to devices of the prior art.

Because of the above described distinct, novel, and non-obvious differences of the present invention relative to Terao, Davis, and Yamaoka, and because of the significant performance advantages and improvements provided by the present invention relative to the prior art, Applicants assert that the present invention as claimed in currently amended independent Claim 1 is not obvious in light of the prior art and is not obvious in light of Terao, Davis, and Yamaoka when considered alone or in combination.

CONCLUSION

For the above reasons Applicants request that the present invention as claimed in the currently amended independent Claim 1 be considered not obvious in light of the prior art, and that dependent claims 2-6 are allowable as being dependent upon currently amended base Claim 1.

Respectfully submitted,

4/20/2005

Rick G. Brewster

USPTO Reg. No. 35,077